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Presidential Address

Lighting and Social History

By W. E. HARPER, B.Sc.(Eng.), Ph.D., M.I.E.E. (*Fellow*)

Introduction

During his Reith Lectures Professor Butterfield used these words: "History deals with the drama of human life as the affair of individual personalities. . . . The historian is concerned with the thoughts of the human mind and the achievements of the human spirit . . . [with] the full, wild, prodigal, complicated story of the actions of innumerable people." So defined, history gathers within its sweep every activity of man, of which the profession of lighting is one.

It is a function of history to correct the presumption that the achievements of any age are the achievements of that age alone. There is no part of modern life that does not stand in debt to the past. This profession which we represent, and which at first sight seems peculiarly a child of the twentieth century, has been fashioned down long years by diverse social forces—by science, by art, by industry, by trade, by law, by human relations—rising, developing, interacting. It is the play and counterplay in English history between such social forces on the one hand and the art and technology of natural and artificial lighting on the other that I propose to consider in this Address.

1300-1600: Beginnings

Trevelyan has suggested that the best starting point for the study of English social history lies in the opening years of the fourteenth century for England was then emerging as a nation with her own character, her own language, her own culture. It was the age of Edward III and the English bowman, the age of Chaucer and of Wycliffe. It was an age of slow change and the first threads of modern life can be seen in the mediaeval tapestry.

By and large the King's law held through most of the land, but that civil peace was from time to time rudely broken is evidenced by the architecture of contemporary manor houses and not least by their fenestration. In the courtyard walls the defence slits of earlier days had given way to true windows filled by "wicker or fine rifts of oak"; in the walls that faced the moat, however, the slits remained, witnesses to recurrent outbreaks of local violence.

Although the authority of the prelate princes was now being questioned, the temporal power of the Church was undiminished. A third of the kingdom's wealth was in her hands and found continuing and happiest expression in the great wave of ecclesiastical building that gave to England the glory of her thirteenth, fourteenth and fifteenth century cathedrals. These were the achievements of men untutored in science but bold in experiment; achievements that sprang from a social and religious climate where inventive genius, craftsmanship and wealth alike were the servants of true piety. Instinctively these builders used the power of light playing on proportioned and decorated stone and marble to evoke profound emotional response. We can learn still of their secret in the Angel Choir at Lincoln, in the naves at Winchester and Exeter, in the Crossing at Wells, in that loveliest early essay in Perpendicular architecture, the choir of Abbot Wygmore at Gloucester, and in many other places.

The 300 years that compass English cathedral building saw great political and social changes in the life of the people, changes reflected again in the altered design of manor houses. As settled peace came to the land under the Tudors, the defence slits of the fourteenth century were replaced by wide lattice windows and oriels filled, as Harrison quaintly wrote in 1577, "by only clearest glass." At night these gracious homes were lighted from simple chandeliers made of wood or iron and carrying candles

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or dips. Charters had been granted to the Waxchandlers and Tallowchandlers 100 years before and for 200 years and more to come their manufactures provided artificial lighting in the houses of the well-to-do. Candles were not cheap, however, and the poorer people for a long time continued to use the reasonably effective if less elegant rushlight.

Social life in the evenings was largely dictated by the limitations of these light sources, and it is a revealing comment on their value as illuminants that some of the craft guilds would allow their craft to be practised only by day.

With the changing temper of the later Tudor age the province of rich endowment swung steadily from Church to school and university, and the foundations were laid of an education ready to respond to the intellectual challenge of the Renaissance.

As the period reached its climax in the reign of the first Elizabeth social activity quickened on many fronts. Joint stock companies, such as the East India Company, were founded, overseas trade was greatly expanded and a trading system established which, in its essentials, is the trading system of to-day. Coal and metals were mined in increasing quantities, the miners using dips fixed to their caps when artificial illumination was necessary. The cloth trade saw the beginnings of modern factory manufacture and—of particular interest to this Society—the English glass industry was firmly established with the settlement in this country of skilled glass workers from Normandy and Lorraine.

But important as were these enterprises in industry and commerce they pale before the literary splendour of the age, for this was the day of Marlowe and of Shakespeare when "the English language touched its moment of fullest beauty and power." To remember this heritage is not irrelevant for a Society that encourages its members to set in writing their discoveries and their experience.

Judging, as we may well do, this Elizabethan age to be the golden age of our history, it often surprises one to realise that with all its achievements of enterprise and intellect the accepted thought forms were still those of mediaeval scholasticism embodying the science of Greece. And so the physics of sixteenth century England was the physics of Aristotle. Its astronomy was largely the astronomy of Ptolemy with a universe having at its centre a motionless earth surrounded by the sun, moon, planets and stars set in concentric spherical surfaces of clear crystal and moved by Intelligences or Spirits. All this places the age on the farther side of the gap that separates medieval life from modern.

But the awakening was at hand. Scholasticism had been damagingly attacked by Duns Scotus and William of Occam. At home Francis Bacon was pleading the cause of experimental knowledge and on the Continent Copernicus and Keppler were founding a new astronomy and Galileo was establishing new concepts of motion. It was the Renaissance. In Churchill's phrase "the end of the beginning" had come. Conscious scientific effort, without which there would have been no technology of lighting, had started.

1600-1800: Preparation

"The creation of science," John Macmurray has written, ". . . . . is the peculiar contribution of Western civilisation to the development of human life. It is our gift to the world." Against the method of medieval philosophy Renaissance science set the method of observation, deduction and induction that governs scientific work. Powerful mathematics were applied to experimental data and improved methods of observation were demanded.

This scientific revolution, which fanned the flames of man's intellect in the cultural centres of Europe, found quick response in England for it came to a nation whose social climate and intellectual temper were sensitive to new ventures of thought.

It was an environment that encouraged discussion and argument and in 1645 a

society began to meet here in London to exchange ideas in philosophy and science. Seventeen years later this society was incorporated by a Charter of Charles II as "The Royal Society," a title changed in 1669 to "The Royal Society of London for Promoting Natural Knowledge." In the words of its early historian Bishop Sprat, its function was "to increase the powers of all mankind and to free them from the bondage of errors." In it we recognise, however distantly, the parent of this cultural Society in which we are met to-night.

From this setting of the seventeenth century came the first man of science of all time. Had his work been confined to that of his "Principia," the fame of Newton would have endured. But our debt is much greater. We of this Society may properly recall that his first paper was on light. He demonstrated the composite nature of white light; he investigated optical interference and double refraction; from his many studies he concluded that light was composed of projected particles which, as he wrote, "stir up vibrations in what they act upon"—an astonishing prediction of modern wave mechanics. When Isaac Newton left Cambridge and came to London as Master of the Mint the foundations of the science of optics had been laid.

In the 85 years of his life Newton saw the religious and political turbulence of the seventeenth century die away into the tranquillity that marked the reigns of Anne and the early Georges. This quiet century was needed by England and she used it well. It was the age of good taste and high culture. Genius flowered in the arts. Nowhere is the elegance of the period better seen than in an Adam interior. High sash windows set in rooms of simple decoration, delicate colouring and superb proportions gave natural lighting that many would say has never been surpassed in our domestic building. And this in spite of the Window Tax introduced in 1696 by a Government more concerned with its finances than with the art and virtues of natural lighting. Happily the imposition was related to the number of windows and not to their area.

In the theatre the bawdy Restoration plays of Wycherley and his contemporaries gave way to the glittering comedies of Sheridan and Goldsmith, played now by artificial light on stages that boasted the first simple footlights. So began that story of the service of lighting to the drama which has touched the heights of great achievement in our own day.

It was presumably the social life of these times which brought the first effective street lighting to London. As early as 1416 Mayor Sir Henry Burton had ordered the citizens of London to place lanterns or other lights outside their houses for the time between All Hallows and Candlemas, but the decree, though continuing in force until the reign of Anne, was ignored more often than obeyed. And so in 1736 the City Corporation obtained Parliamentary powers to light its streets and nearly 5,000 crystal glass lanterns were erected, the cost being met—you will not be surprised to hear—by levying a rate.

This eighteenth-century England was still largely rural England, but commerce and industry were expanding and slowly people were being drawn from the land to meet the needs of developing trade. The iron trade of the Black Country was growing and coal output was greatly increased. In 1765 Mr. Spedding, a colliery manager, lighted his own offices by coal gas and in 1798 William Murdoch installed gas lighting in the foundry of Boulton and Watt at Soho.

With the growth of overseas trade came increase in merchant shipping and the call for navigational aids at night. The first two regular lighthouses had been built at Caister in 1600 but had as their light sources only one or two candles. The first light to use a multiple candle source was the Eddystone in 1698, and the practice was continued when Smeaton built the third light at that point in 1759, the candles being mounted on a large corona. Liverpool, on the other hand, followed American practice and installed oil lamps as early as 1739. The North Foreland

replaced candles by oil in 1787 and by the end of the century Argand lamps were in wide use. The lights were still steady, the first experiments with flashing lights not being made until 1811.

In such events one can detect deep within the complacent and stable life of eighteenth-century England the murmur of that Industrial Revolution which, within less than 100 years, was to change for ever the pattern of society. Precise dates cannot be set to great social changes, but as we mark this century drawing to its close we know that here is one of the great divides of our history.

1800-1900: Development

Of the many factors that interacted to produce the Industrial Revolution none was more powerful than the changed relation between science and industry. Previously they had largely gone their own ways. From now on science was to respond increasingly to the demands of industry and industry to apply the discoveries of science.

As the eighteenth century drew to its close manufacture was passing quickly from cottage to factory, from countryside to the new industrial towns. With the inventions of Arkwright and Watt, of Trevithick and the Stephensons, mechanical power came to the factories, to the mines and to transport. Capital was poured into industry and demands for labour grew swiftly. A new pattern of social life—industrial urban life—evolved, all too often in a manner that was ugly and degrading. The vulgarian creators of early nineteenth-century industrial England had no time for the culture and beauty that had marked the eighteenth century, and values of elegance and humanity were sacrificed on the altars of utility and quick profit. This period of English social history is a period stained by evils that rose from appalling conditions of life and employment, but the picture is not wholly dark as some commentators would have us believe. In spite of much real suffering among the people, the average standard of living rose considerably and progressively. Social legislation to rectify the worst features of industrial and communal life was introduced on a scale and with a rapidity that are remarkable even to-day. In 1833 came the first effective Factory Act and nine years later the first Mines Act. To enforce their provisions Factory and Mines Inspectorates were set up. Primary education was made compulsory and the employment of children in industry severely restricted. The second half of the century is marked by a continuous and growing sense of social responsibility and by a warm philanthropy.

Through these years England dominated world trade, the products of her multiplying industries finding full outlet in overseas markets. Wealth flowed into the treasury of the nation.

Improved communications within the country and across the seas were essential to sustain this great industrial expansion. At home the early railway systems were rapidly developed and sail was progressively replaced by steam at sea.

As each component of the new industrial society was fashioned so, unconsciously, it created a demand for artificial lighting matched to its characteristics. Realisation of this demand and effective answer in the form of an organised lighting profession were as yet far off, but social pressure already was operating to that end.

For the time being, however, response was spasmodic and isolated. It came first, and rightly, at the point of greatest need—the lighting of the mines. For generations miners in gassy pits had worked in conditions of great danger. In 1708 100 men had died in an explosion at Chester-le-Street and two years later 80 at Bensham. As pits were driven deeper the number of explosions increased. Attempts to provide safe lighting in the presence of explosive methane/air mixtures were made by several investigators, but success was partial until in 1815 Humphrey Davy gave to the mining

industry his safety lamp. It was an invention whose value to the nation it is impossible to compute.

Elsewhere the traditional light sources became progressively inadequate to the needs of society and, in spite of opposition by interests vested in the tallow and oil industries, the new gas lighting rapidly gained ground. A cotton mill was lighted by gas in 1805; in 1809 gas lighting was installed in Pall Mall and five years later Westminster replaced the oil lamps in its streets by gas lamps. The Gas, Light and Coke Co. was granted a royal charter in 1812 and during the next 20 years gas works were built in many towns. The change from individual sources of light to sources supplied with energy from a central point is one of the most important changes in the history of artificial lighting.

But even as gas lighting was being established, work that would result years later in its supersession was in hand. As early as 1809 Davy demonstrated his electric arc lamps with current drawn from a battery of 2,000 cells. It was a spectacular demonstration, but electric lighting had to wait until a source of supply more convenient than the battery was available. The advance came when, here in this Royal Institution, Michael Faraday elucidated the principles of electromagnetic induction and by his brilliant investigations opened the way to the design of the generator and to the electricity supply industry of to-day.

At much the same time the young Joseph Swan began his experiments on incandescent electric lamps. Laid aside for a time, the work was brought to success in 1878. A year later Thomas Edison, in the United States, filed his patent on the carbon filament lamp and the electric lamp industry was born. Application followed close on invention. Within two years Sir William Armstrong and Lord Kelvin were using Swan's lamps to light their houses. A year later filament lamps were installed in a number of public buildings, including the Royal Academy and the British Museum. As the use of electric lamps increased fittings designed specifically for them were developed, among them the prismatic glassware of Blondel and Psaradouki.

Throughout these years of swift advance fundamental scientific studies that were to serve the practical lighting demands of the future had gone forward on a wide front. There had been Clerk-Maxwell's electromagnetic theory of light and Rayleigh's theory of molecular scattering, Ramsay's work on the rare gases and the researches of Crookes and J. J. Thomson into the discharge of electricity through gases. In the field of light measurement Vernon Harcourt had developed the pentane standard, Ritchie and others the early photometers and Sir William Preece had realised the importance of measuring illumination.

So, slowly, scientific research and industrial development forged tools to give answer to the now clamant demands for better artificial lighting. Answers were given but still largely piecemeal. Effective answer waited on the conception of lighting as a service to society, as a new branch of technology able to integrate advances in knowledge in many related fields of study and to apply that knowledge to diverse problems. This could not come by individual effort alone; a lighting profession was demanded.

1900-1956: Achievement and Opportunity

For this country that demand was met when, on February 9, 1909, it was agreed to form an Illuminating Engineering Society. The draft constitution was ratified on May 25 and on November 18 of the same year Professor Sylvanus P. Thompson delivered the first presidential address. The British lighting profession was founded. No longer would lighting be a by-product of the gas and electricity industries; it would become a formative power in shaping the social life of the people.

Evidence that indicated a growing official recognition of the importance of good lighting gathered quickly in the early years of the new century. The City of London appointed a deputation to investigate methods of street lighting in Continental

cities; the Medical Officer of the L.C.C. drew attention to the need for better lighting in schools; a Government-sponsored competition was organised to develop electric hand-lamps for use in the mines; in 1912 the Home Secretary set up a Departmental Committee to inquire into the natural and artificial lighting of factories and workshops—an inquiry that gave rise to the great survey made by Walsh and Sedgewick; a year later, largely on the initiative of our own Society, the International Commission on Illumination was formed "to study all systems of lighting and technical problems connected therewith."

These years, filled as they were by technical progress, were politically years of unfamiliar and growing apprehension in England. For a century and more she had been the island centre of a vast overseas empire. Secured by naval power she had been unmoved by the affairs of Europe. But now all was changed. Inextricably involved in European politics she faced the greatest war of her history and for four years everything was sacrificed to survival.

When at last peace came certain facts stood clearly in relief. Under the stress of total war the familiar social and economic patterns of English life had disintegrated; greater equality of income had been established; the authority of the trade unions had risen and Socialism was now a major political power; mass production was general in most industries. Perhaps most important of all the war had shown how far we had fallen behind Germany in applied science.

British industry was not slow to admit this shortcoming and to meet its challenge. Under private enterprise industrial research establishments were created which were to play a major part in the systematic application of scientific method to industrial problems. It does not decry the wealth of research effort in universities and Government departments to suggest that the remarkable progress in lighting that took place in the 30 years following the First World War came predominantly from the laboratories and technical departments of the electrical industry.

Their achievements are now so much a part of our modern life that it is difficult to recapture the air of exciting advance in field after field of practice that marked those years. The production of the popular car and the rapid increase in road transport brought an imperative need for a new order of street lighting. Air travel was being established and the fundamentals of airport lighting had to be investigated. The production demands of industry called for higher levels of illumination and attention to problems of glare. Popular entertainment found focus in the cinema and the development of studio lighting systems was required. Pre-war hospital operating theatre lighting was inadequate for modern surgery and the lighting techniques used in small shops for the modern large stores. To translate the studies of the illuminating engineer into practice new tools were needed and supplied. New light sources—incandescent and discharge—were developed. Methods for light control by refractor and reflector were devised and applied. From other industries came new materials for use by the designer of lighting fittings—new glasses, new metals, new enamels and paints and the first synthetic organic plastics. The quality of lighting equipment was raised by attention to standardisation and by improvements in photometric measurement.

Behind the thrust of this applied research painstaking investigations that secured the advance went forward. Notable among them were researches into vision and that long series of tests from which came British flameproof fittings to bring a much greater safety to the lighting of hazardous locations.

Throughout this twentieth century, in peace and in war, the pattern of social life in England has swiftly changed with consequences that touch the lighting profession at many points. But as social demands have shifted and grown so have our resources expanded until the gap between demand and response has been bridged and to-day there is little that is technically impossible. Indeed the present danger

is that in our technical competence we become complacnt in approach and fail to seize the opportunities of the times.

Modern life with its sense of emergence from the cultural sterility of a hundred years, with its growing recognition of the poverty of utilitarianism, with its air of industrial adventure and its rising production confronts the lighting profession of our day with claim and opportunity as challenging as those of any age in the history we have passed in review. If this Society, representing as it does the lighting profession of the country, is to rise to its social responsibility within the contemporary life of the nation, then its policy should, in my opinion, be marked by three principles among others :—

First is the principle of *catholicity*. There is little of present-day life that is not affected—and often deeply affected—by the art and technology of lighting. Subconsciously most of us are aware of the wide sweep of our interests, but it is necessary to lift this awareness to the level of conscious purpose if we are to realise the opportunities that are ours and to negate the temptation—always lying close to professional societies—of becoming ends in themselves, exclusive and self-satisfied in outlook. This is a time to move out beyond traditional boundaries and to draw within the Society members from walks of life other than lighting whose interests are served by its practice. To an extent we have done this in the past but there is large scope still before us. I think, for example, of many engaged in industrial safety and welfare, in medicine, in the theatre, in education, to whose work lighting is of great concern and whose membership would add much to the strength and influence of the Society.

The second principle on which I would comment is that of *authority*. There is little doubt that this country is in the closing phase of a transition from the *laissez-faire* capitalism of the nineteenth century to a planned economy. With this change has come increasing control by Government and municipal bodies over large areas of public life, a control that carries with it certain dangers. Of danger alike to professional interests and to the best interests of the community is the growing tendency for Government departments and committees to assume an authority in technical matters over-riding that of the professional bodies. This I hold to be a mistaken assumption for the final authority in any province of science or technology does not come from appointment, however distinguished, but resides in that total knowledge and experience of all members of the profession, of which societies such as this are the expression and the guardians. In lighting it is an authority held by this Society and by this Society alone. It is an authority that none the less can be lost by neglect and we would do well wisely and constantly to exercise it at national and local level in all matters of public concern related to lighting.

Finally, there is the principle of *responsibility*, the principle which recognises that our professional work cannot be separated from the social life that shapes all our activities and from which we draw the very reason for our existence. There is a school of thought that would absolve scientists and technologists from social responsibility, enabling them to produce the atomic bomb and then wash their hands before its cloud over Hiroshima. Such a cleavage between action and responsibility I believe to be as indefensible morally as it is false to reality. For good and for ill our professional activities are woven into the social fabric with consequences ineradicable from the history of our times beneath whose judgment we most surely stand. Lighting is deeply implicated in man's welfare and happiness, and the responsibility for its effective and proper execution lies upon each member of this Society.

It is a responsibility that can be fulfilled only as we are united in an accepted purpose of service to the community and I would commend to you some words of Edmund Burke :—

" No men," wrote Burke, " can act with effect who do not act in concert; no men

can act in concert who do not act with confidence; no men can act with confidence who are not bound together with common opinions, common affections and common interests."

If this Society is so bound together in motive and purpose, we can move into the times of change and decision that lie before us unafraid that we shall fail the great heritage that is ours.

Vote of Thanks

Dr. W. J. Wellwood Ferguson, proposing a vote of thanks to Dr. Harper, said: To see ourselves in perspective is at once a difficult and salutary task. It enables us to take a humbler and perhaps more realistic view of our current ideas than we are normally accustomed to. Dr. Harper has succeeded in doing this in his masterly survey of the social, artistic and historic backgrounds of the art and science of lighting. He has stressed the importance, to societies such as ours, of recognising and accepting their responsibilities, and, in particular, of upholding and strengthening their sense of professional responsibility in technical matters—a function, as he has said, at present too apt to be usurped by governmental control.

His plea for catholicity, too, was one which greatly appealed to me, as the technical means now exist to make the art of artificial lighting as important and satisfactory as was that of natural lighting in the days of the cathedral builders, and of the Adam brothers.

I am glad to take this opportunity of congratulating Dr. Harper on his stimulating and admirably delivered address, and in proposing a most hearty vote of thanks.

Mr. W. R. Stevens, in seconding the vote of thanks, said: The first major task with which our new President is confronted each year is to prepare and deliver an address at our opening meeting. So much has been said, and so wisely, by our previous Presidents over nearly 50 years that it would seem impossible to find something new and worthwhile to say, but Dr. Harper has succeeded in doing so in the very best manner. Not only has he said something interesting, but he has said it in an unusually attractive manner. Quite clearly he is a worthy successor to many distinguished predecessors.

Our President has quoted Burke, and I would like to do so as well: "Your representative gives you, not his industry only, but his judgment; and he betrays instead of serving you if he sacrifices it to your opinion."

We know that Dr. Harper is a man of considerable judgment. I think we may take it, too, that although he will co-ordinate our combined opinions wisely, he will not hesitate to exercise his judgment as our leader. We may, therefore, look forward to another full and successful year of the Society's activities.

In seconding this vote of thanks I would express the hope that he will find his year of office happy and not unreasonably onerous, and I would offer to him and to Mrs. Harper the very sincere and good wishes of all of us.

New Lighting Development in Germany

By L. SCHNEIDER

Summary

The development in any country of any branch of technology depends not only on the development of theory and basic knowledge but also on the availability of raw materials, standards of craftsmanship and technical ability and on economic factors. This applies to the development of lighting and, in particular, to the technique of application; this is evident from a study of lighting in different countries and applies equally in the case of Germany.

The main part of the paper is concerned with lighting practice in offices, schools, shops, theatres and churches. There is also a section dealing with recent developments in railway lighting in Germany.

(1) Development of Lighting Technology

The development of any branch of technology in a country does not depend solely on the extension of technical knowledge of facts, underlying theories and the laws derived from them. It is influenced also by the nature of the raw materials available in the country, the extent to which craftsmanship and technology have been developed and not least by economic considerations and necessities.

Influences such as these are to be noticed in the development of lighting technology in different countries, especially in the field of illuminating engineering, the application of light. In Central Europe, especially in Czechoslovakia and Germany, there has been in existence for many decades a highly developed hollow-glassware industry. The factories are not very large and even to-day handwork is used to a large extent, i.e., the glassware is blown from the mouth. When, in the twenties of this century, lighting technology encouraged a demand for diffusing glassware of high transmission, this demand could be satisfied by the production of so-called flashed opal glassware. The production of this glassware by hand calls for long and arduous practice, since getting the very thin coating of diffusing glass depends entirely on the skill of the glass blower. These experienced craftsmen are very reluctant to move and it is difficult to transplant them from their homes to other countries. It is quite easy to see, therefore, why in Germany good lighting fittings were made almost exclusively of flashed opal or opal glass. In other countries such as England, France and the United States, such craftsmanship is much less common. This clearly led to the development in these countries of high precision methods of moulding glass, so that interior lighting fittings made of prismatic glass were widely used in these countries, whereas in Germany their use is practically unknown.

A similar development can be noticed, too, in street lighting fittings. Thus, for example, in the United States prismatic fittings with a strongly directional light distribution are employed, because in the United States the fittings cannot be suspended centrally over the roadway. Since in the large cities, too, the main traffic streets are very wide and carry heavy traffic, high values of luminous flux must be directed from the kerbs towards the carriageway. This can only be done conveniently by the use of optical devices, mirrors and prisms. In Germany very wide streets are rare; streets of medium and narrow width predominate. The fittings are generally suspended over the centre of the carriageway on span wires, this method of mounting making it possible to use simpler fittings with a less highly directional light distribution. Thus, for the last 25 years a simple fitting with an opal glass shade, open at the bottom, has been very widely used as a street lighting fitting, both for tungsten filament lamps

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and, later, for high pressure mercury vapour lamps. The attempts, made repeatedly in our country from the early twenties, to introduce prismatic street lighting fittings with a pronounced directional light distribution came to nothing. Undoubtedly the considerable weight of such fittings was one reason for this, since this factor is more important with overhead suspension than when the fittings are mounted directly on posts.

If we compare the light sources used for street lighting in different countries here again we can notice divergent tendencies in development. In the United States, especially in the large cities of the east, the use of filament lamps is still quite predominant. This is easily explained by the fact that a large investment has been made over many years in street lighting installations with filament lamps. In the large cities, and particularly in the city centres, the series system installed at the time of the magnetite arc lamp, is still largely employed. The price of current is low, and there has been no destruction of the street lighting installations, as in Europe, so that there has been no pressing urge to reconstruct these installations with modern discharge lamps. High pressure mercury lamps are primarily installed in the United States in places where new streets are constructed, especially in the western regions.

In Great Britain, sodium and high pressure mercury vapour lamps have been used more widely since the war for street lighting, including the lighting of city streets. As far as my information goes, this development is influenced by the fact that when street lighting is renewed, light sources with as high an efficiency as possible have to be employed for the sake of economy in current and fuel.

In Germany, after the war, the street lighting installations were almost completely in ruins, the supply plant was too small and the distribution systems were inadequate. For some years after the war only filament lamps were available so that the first meagre restoration of street lighting was done with them. To provide those fittings with opal glass shades, which had previously been widely used for street lighting as mentioned earlier, was very difficult because the hollow glassware industry was located in the eastern part of Germany and so was behind the Iron Curtain. It took five to six years before the factories which moved from there into Western Germany were constructed and could begin slowly to restore the supply of diffusing glassware. In the meantime the fluorescent lamp reappeared on the market. Its high efficiency as compared with the filament lamp was very much in its favour, having regard to the inadequate power supply and the restricted distribution systems. The lanterns used for these lamps required no glass bowls and no highly diffusing glassware. The walls were ordinary flat glass plates and the internal reflectors were of aluminium, or else the fluorescent lamps were housed in rectangular boxes the sides and bottoms of which were glazed with sheet glass. This is the reason why the renewal of street lighting in Germany was carried out predominantly with fluorescent lamps, and another reason is that the lantern makers developed, one after another, better and better lanterns designed to meet practical needs. These are constructed shallower than previously, are fitted with two or three fluorescent lamps and give only slight glare. The fittings are generally suspended over the carriageway at right angles to the street axis, two rows of lanterns being used for wide streets. By using lanterns with a marked downward concentration, arranged parallel to the street axis, it is possible to obtain a better distribution of light over the carriageway, with higher efficiency and complete freedom from glare, but the installation costs are higher (Fig. 1). The overhead span wires do not improve the appearance of the street, and on this account there is a noticeable tendency of late to mount the lanterns on so-called "horse-whip" columns erected at the sides of the street so that, owing to the shape of the columns, the lanterns project over the street surface. Gas street lighting, too, has followed this line of development, 6 to 12 mantles being arranged in a line. The resulting elongated lanterns are likewise suspended on horse-whip columns. Soon after the war, blended mercury-tungsten

Fig. 1.

Table 1

Light sources used for street lighting. (1954)

Light source	Per cent.
Tungsten filament	62
Fluorescent	25
Mercury-tungsten	7
Mercury vapour	6
Sodium	less than 1

lamps were in many cases inserted in existing lanterns designed for filament lamps, because no choke was required with these lamps and their life being longer than that of filament lamps, the cost of renewal was less. Of late it is noticeable that there is a growing tendency to favour the high-pressure mercury vapour lamp with fluorescent bulb as against the fluorescent lamp. These lamps, when compared with the mercury-tungsten lamp, have the advantage of a considerably higher efficiency with a longer life so that they are more economical in spite of the need for a ballast, especially in the larger sizes which are needed for street lighting to provide the higher values of illumination frequently demanded. The use of mercury-tungsten lamps is therefore becoming more and more confined to existing installations. With high-pressure mercury vapour lamps no prismatic glassware has so far been employed. These lamps, too, have been used in the ordinary simple street lantern up to the present, but lately they have been used also in mirror fittings for two lamps. Table 1 gives an idea of the relative numbers of the different electric light sources used in street lighting, these account for some 52 per cent. of all street lighting fittings, the remaining 48 per cent. being gas fittings.

The examples given above show quite clearly that the development of lighting technology is not governed solely by technical requirements, but that the influences

mentioned in the introduction play a part in it. It is therefore understandable that the application of light in different countries should be accompanied by different solutions of lighting problems. I would, therefore, urge that the development of lighting in our country, which is described in what follows, and which in many respects differs from practice in other countries, should be considered from this point of view.

(2) Glassware for Decorative Fittings for Filament Lamps

Because of the highly developed craftsmanship in the industry responsible for the production of glassware for lighting fittings, glass, in the past decade, has well maintained its position *vis-à-vis* other materials such as silk, alabaster or paper in the construction of decorative fittings. After the migration of the various glassworks to Western Germany, there was evident a marked preference for modern designs and for surface decoration in harmony with the tastes of the present day. Twenty to thirty years ago the lighting engineer recommended that, for the prevention of glare, decorative fittings should have opal instead of clear or matt glass and should be of a shape which was advantageous from the lighting engineer's point of view. Whereas in the case of industrial fittings the monotony of appearance of the opal glassware was not noticeably annoying, in decorative fittings this monotony was avoided by painting the opal glass with bright colours, sometimes by hand, sometimes mechanically. This, however, led to a deterioration in æsthetic standards. From about 1950, new designs of glassware in contemporary style were produced under the direction of an artist, Prof. Wagenfeld, who had similarly created new forms for many other subjects in use in daily life; at the same time new methods of finishing the surface of the glass were developed. The first was a heavily depolished clear glass with fine lines left clear, or with narrow clear bands harmonising with the shape of the glassware. A further development gave the dying art of glass painting a new lease of life technically. A white or lightly tinted diffusing colour is sprayed on to the clear glass, and thin lines or narrow bands are scored out of the uniform diffusing layer before the colour is burnt in. In this way the dead surface is brought to life without causing glare, the light from the filament lamp shining through the clear lines giving the lighting a lively appearance. The same process is also applied to opal glassware in which the colour is generally light in tone. The uniform bright surface (Fig. 2) is thus enlivened, and by appropriate design such glass fittings can be made to harmonise with the most varied kinds of room decoration. The high absorption of the glass which results from the application of the colouring material is of secondary importance in comparison with

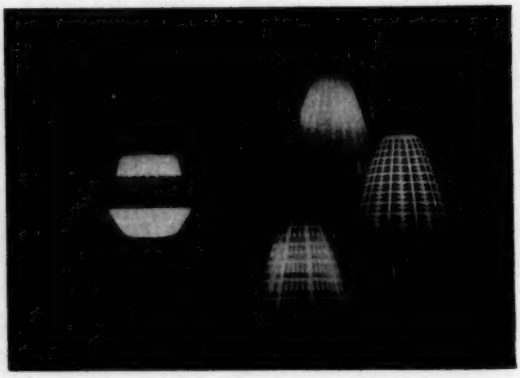


Fig. 2.

the æsthetic gain. Wagenfeld has explored an interesting line of development by using two-piece fittings in which the inner element, of opal glass, diffuses the light and distributes it appropriately, while the outer clear glass bowl is decorated with lines or designs in the way described above. By this means the dull effect of opal glass is removed and the fitting ceases to have the heavy look associated with that material. This outer glass can be given an individual and more markedly artistic note if the lines are drawn in freehand or with a comb. Wall fittings which are well shaped and interesting in appearance have been produced in a similar way.

For decorative fittings, plastic bowls have very little vogue compared with glass. Production in this material necessitates costly tools for extrusion or moulding. Apart from their inferior resistance to heat, these products lack the note of individuality possessed by glass which is produced by hand and the surface treatment of which exhibits the artist's handwriting. The wide variety of shapes demanded by the public is easier and cheaper to produce in glass, since the articles are made by hand and therefore no large investment in machines and tools is necessary. However, shades made of paper or of pleated plastic sheet are used.

(3) Fittings for Fluorescent Lamps

As already mentioned, it was several years after the war before fluorescent lamps reappeared on the market; when they did appear there were no fittings for them. First of all the production of sockets and ballasts had to be organised. The first fittings produced were mostly simple troughs and reflector fittings with aluminium mirrors, either open underneath or closed with sheet glass, or else the rectangular box fittings mentioned earlier, with windows of sheet glass, which were easier to produce than hollow glassware because of the wide use of window glass. The need for a more effective and wide distribution of the emitted light flux without glare led to the development, side by side with the use of metal or polystyrene louvres (polished, fluted, transparent, white, black, rectangular, slanting, round), or flat or curved glass plates with surfaces of different forms (e.g., fluted, pin-head morocco, or with tiny pyramids). At the same time plastics were used increasingly as light-diffusing materials. For interiors, too, there has lately grown up a demand for dustproof and insectproof enclosed fittings, in order to reduce the frequency of cleaning. On the other hand, there is a growing demand that it should be possible to clean fittings from floor level with a mop or sponge fixed to a pole, for which purpose the enclosing surfaces must be of glass because of its strength.

Glass is cheaper than plastic, but on the other hand it is heavier, is often greenish, the risk of breakage is greater, and there is the possibility of injury due to falling glass. On this account plastic fittings without visible metal parts are often preferred, especially for outdoor use (reduction of weight, with lighter suspensions and brackets). To-day, equipment made of " plexiglass " (methyl methacrylate) or polystyrene is used; the latter is cheaper but its fastness to light is not yet fully established. For both materials mass production is essential, since the tools needed in their manufacture are very costly.

Flat or curved sheets of glass with surfaces ornamented in the manner described earlier are now frequently used in built-in architectural lighting schemes.

(4) The Lighting of Offices

For the illumination of offices and similar interiors with light-toned ceilings and walls, general lighting had become very popular before the appearance of the fluorescent lamp, i.e., in the thirties. Fittings with a semi-direct or uniform light distribution were placed between the windows and the desks; in deep rooms with several desks side by side there was a second line of fittings parallel to the first at the end of the row of

desks. After the war this tradition was followed when new offices were equipped and old rooms improved. To-day in office lighting the use of fluorescent lamps predominates to a very great extent. Seven to eight years ago the fluorescent lamps were mounted on battens on the ceiling or close to it. In course of time, as the number of suitable fittings on the market increased, these were more and more widely used, but even to-day installations of bare fluorescent lamps without any fittings are still to be found in considerable numbers. Sometimes small transverse fins of white plastic are mounted directly on the tube to prevent glare. At first the low luminance of the fluorescent lamp led to the use of lamps or fittings mounted at right angles to the window wall and therefore parallel to the desks. This occurred chiefly in large rooms with girders where the architects wanted the rows of lamps or fittings to be arranged parallel to these girders. However, the reflections in the desk tops produced by this arrangement proved annoying. Nevertheless, if semi-indirect fittings are used with an illumination of 400 lux, the amount of reflection is not great. The fittings used to-day, therefore, have louvres below and sides of matt glass or lightly diffusing plastic, or else they are designed as enclosed fluorescent lighting fittings.

To-day fittings are always parallel to the window and close to it, mounted on the ceiling or, in lofty rooms, suspended on rods of suitable length. In addition, especially in deep rooms, a second row of fittings is mounted at a distance from the window equal to about two-thirds of the room depth. Lately so-called " corner fittings " have become important. They are mounted in the angle between the ceiling and the window wall and often in the opposite wall as well (Fig. 3). The lighting efficiency is naturally somewhat lower than that of suspended fittings. On the other hand the impression created by the room is not marred by large fittings suspended inside it. It is not yet clear how the light distribution from corner fittings and from fluorescent fittings mounted directly on the ceiling ought to be evaluated, because the light distribution of these fittings may be very different from that of a suspended fitting as determined in the laboratory, for example, with moving mirror apparatus. Consideration is being given to the use of an auxiliary ceiling and, where appropriate, an auxiliary wall as well, to give the effect of the way in which the fitting is mounted, and on this basis

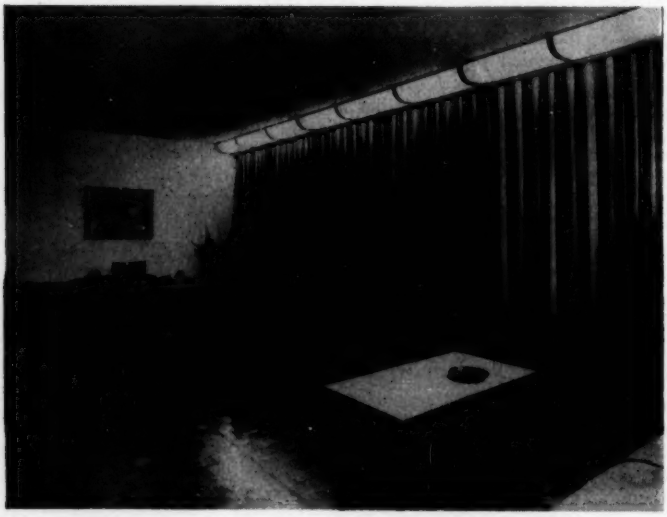


Fig. 3.

to specify a method for the determination of the light distribution. The problem is not a simple one, since the extent of the auxiliary ceiling affects the distribution curve.

In large offices, lines of light (bare fluorescent lamps) or bands of light (elongated fittings) are used, arranged as described above. The lines or bands of light are always either mounted on the ceiling or, in lofty rooms, at a suitable distance from it by means of rods. Continuous fittings built into the ceiling, such as are widely used in the U.S.A. (troffers), are little used in Germany. These built-in lighting fittings presuppose a false ceiling which in the U.S.A. is usually available as an acoustic or sound-absorbing ceiling. Such ceilings, however, are little used by us for economic reasons. If the bands of light are built into the ceiling, the contrast between the band and the ceiling is very great since the ceiling receives no direct light from the fittings. This contrast is only reduced if, as is often the case in the U.S.A., the illumination is much higher than with us, i.e., of the order of some 500 to 1,000 lux, when the lighting area is at least one-third of the ceiling area.

In Germany the average value of the illumination in offices is about 250 lux, but higher values, such as 400 lux, are not exceptional. In small offices, for one or a few occupants, troubles such as fatigue can result from high values of illumination if the walls are white. If the lighting of the room is uniformly diffused the luminance of the white wall is, of course, greater than that of the working area and objects in it. This trouble can only be avoided by reducing the luminance of the wall by tinting it, which also improves the appearance of the room.

(5) The Lighting of Schools

In the construction of new schools, modern building design, based on that of the U.S.A. and having a large window wall on one side, has been adopted in certain cases. Often these rooms have moveable tables. The greater number of schoolrooms, however, are still built on traditional lines and have the old arrangement of seats. Fluorescent lighting has not yet been widely adopted in schools; lighting by filament lamps is predominant, and this applies especially in ordinary schools where there are no evening classes. With ordinary teaching periods, the hours of darkness when artificial lighting is required are only a small percentage of the whole, and on account of the restricted period of use of the lighting system, fluorescent lighting is less economical than tungsten filament lighting. In schools with evening classes, such as technical schools for instance, fluorescent lighting has made considerable headway.

For tungsten filament lighting, special fittings with concentric metal rings are now often used, as in the case of American schools.

(6) Shops

The fluorescent lamp has brought about a fundamental change in the constructional form of medium sized shops and stores. In the old days of lighting by tungsten filament lamps alone, these stores had large light wells to admit enough daylight into the different floors. The sales rooms distributed over the different storeys were, so to speak, built around one or more light wells. The result of this was that only on the ground floor could the whole area of the site be used as selling space. The high efficiency and the satisfactory colour of the fluorescent lamp have now made it possible to provide sufficiently high illumination during the day, so that light wells have become superfluous. All new stores built in Germany since the war (most of the buildings were destroyed in the war) have no light wells. The greater selling space thus obtained now makes it possible to sacrifice part of the ground floor to provide for the extension of shop windows and show cases. In most newly-built stores and the larger multiple shops, arcades are included in the construction for this purpose; they, too, require all-day artificial lighting. The light falling on the path from the shop windows and show

Table 2

Examples of increased annual hours of use with fluorescent lighting

Installation	Former (1950-51) Tungsten lighting only	Present (1953-54) Predominantly fluorescent	Increase (per cent.)
Koster's Stores, Wiesbaden			
Connected load	37 kw	50 kw	35
Power consumed	77,000 kwh	136,000 kwh	76.5
Hours of use	2,070	2,720	31.5
Frey Fashion House			
Connected load	10.7 kw	15.4 kw	44
Power consumed	16,500 kwh	61,400 kwh	272
Hours of use	1,540	4,000	160

cases is usually sufficient to light the whole arcade, but often a low-intensity lighting for pedestrians is provided and lately this has been combined with radiant heating. These arcades make it possible to exhibit many more articles to the shopper without any need to encroach on the selling area. Since they also provide a welcome protection against bad weather, they invite lengthy inspection during rainy or cold weather and encourage a desire to buy. The canopies which are frequently built on to shops serve to protect the passer-by from the rain and induce him to look at the goods. Apart from the fact that they may provide protection from sunlight, they have no special lighting function.

This development is of great importance in the economics of electricity supply, since the artificial lighting of the buildings is used not only after dark but all day long. This means that the so-called lighting peaks in the supply load are flatter and the operating time of the installation is increased. Naturally, too, the connected lighting load is greater. This is illustrated by two examples, given by Dr. Jacob and based on two shops in Wiesbaden (Table 2). Similar trends are noticeable for other types of lighting use, e.g. offices. The higher level of illumination results in longer periods of use, especially in dull weather and on dark days, when the lighting is switched off later in the morning and put on earlier in the afternoon, except in gloomy rooms where it is in use all day. This, too, makes the lighting load more important to the supply authority.

In medium sized and small shops the arrangement of the counters, the shelves and the special display stands is fixed, consequently the lighting fittings giving general lighting are arranged in relation to the counters, etc. Large shops generally make a practice of rearranging the counters and display stands from time to time, especially for particular selling occasions such as sales, the period just before a special season such as Easter, and so on. It follows that the lighting in these shops must be so arranged that it suits differing arrangements of counters and stands.

This requirement can be met in two ways. Either the lighting system can be so designed that the fittings are movable, or alternatively it can be designed to give a good uniform general illumination while reflector lamps can be used to provide supplementary lighting. The prototype of the first alternative is the Rotterdam ceiling. In this construction, however, a large part of the surface of the ceiling is dark and it is even black in many cases so that the appearance of the room is distorted. Doubtless it is partly due to this unsatisfactory effect that in Germany the number of Rotterdam ceilings has diminished and that, as far as can be seen, they are no

Fig. 4.

longer a feature of new construction. The scheme of painting the ceiling black and mounting, at a suitable distance from it, fittings which emit all their light downwards is used in a few cases for other reasons. Thus, there is a store which in the course of years has absorbed a number of neighbouring buildings, and has extended its sales rooms into them. The ceiling heights of the rooms in these other buildings are not the same as that in the store. In order to give the large selling area a uniform appearance (Fig. 4) fluorescent lamps were mounted at the same height above the floor in all parts of the room, and the ceiling and those parts of the walls above the level of the fittings were painted black. As a result, these parts of the building disappeared and the impression received was of a large room of uniform height. In another case, bands of light were arranged in grid formation at a certain distance below the ceiling and again the ceiling and the parts of the walls above the lighting fittings were blackened. All the supplies, tubing, etc., were mounted in this space and could not be seen from inside the room. The effect of such schemes is enhanced as the ratio of the lighting area to that of the whole ceiling area increases.

The second solution, viz., a good uniform general lighting, suggests the use of an illuminated ceiling and this can be more readily achieved with fluorescent lamps than with filament lamps. In very large rooms of low ceiling height, however, such an illuminated ceiling seems oppressive and dull. Apparently this is connected with the fact that, for the same illumination, the luminous flux needed is smaller with a low room than with a high one so that the luminance of the ceiling is lower. Further, for normal viewing conditions, a larger part of the ceiling comes into the field of view in low rooms. It must not be forgotten, too, that the luminance of such a ceiling is always somewhat uneven owing, among other things, to the unequal degree of soiling in different areas and to the different amounts of flux emitted from fluorescent lamps at different stages of their life. These differences are much more noticeable in a low ceiling, since the eye sees the surface of the ceiling foreshortened and the areas of higher and lower luminance are thus brought close together. In consequence, illuminated ceilings are only to be recommended in lofty rooms. Installation costs, naturally, are higher than for the more usual lighting schemes with separate fittings and cleaning is more costly. A well-illuminated bright ceiling, too, may be monotonous and for this reason different methods have been tried out to enliven it by the

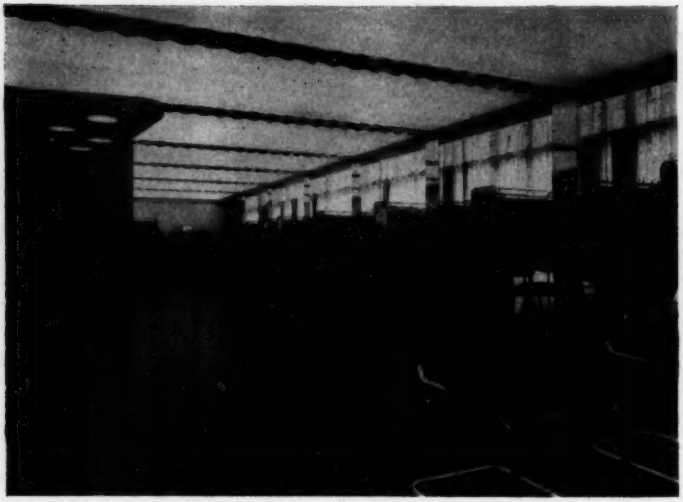


Fig. 5.

use of painted glass or by the employment of different kinds of glassware. Lately, attention has been directed to breaking up the lighted surface with broad reflecting aluminium strips (Fig. 5). Generally speaking, it can be said that illuminated ceilings are comparatively seldom used in shops.

Instead of illuminated ceilings, individual lighting fittings, bands of light, etc., are generally used for the lighting of sales rooms. Lately, square or circular lighting areas of strongly or weakly diffusing material built into the ceiling have been found satisfactory as regards both lighting efficiency and æsthetic appearance. Lines of light mounted on the ceiling or, more frequently, built into it are common. In contrast to the effect of the black ceiling, described above, rooms so treated appear very shut in. As is well known, a space only gives the appearance of being enclosed when its bounding surfaces, i.e., ceiling and walls, are visible.

Side by side with these installations, which are good from both the lighting and the artistic points of view, lines of light consisting of bare fluorescent lamps mounted on battens are not infrequently employed. In particular, shops which deal in cheap goods as, for example, one-price stores, favour such a simple lighting scheme without much decorative effect. This is due to the fact that in order to sell the goods as cheaply as possible, efforts are made to keep all expenditure as low as may be and the high illumination desired is obtained in the simplest possible way without great expense. So lines of light with bare fluorescent lamps are used to avoid absorption in fittings and to reduce loss by the collection of dirt. To reduce glare, transverse louvres of diffusing plastic are often mounted on the fluorescent lamp.

The use of reflector-type tungsten filament lamps for making conspicuous special articles or groups of articles is also on the increase with us. To a small extent mirror fittings are used for this purpose. This also provides a means for emphasising changing displays or special goods, quite simply, by means of higher illumination in a shop with good general lighting.

The erection of new shops and stores is not yet finished. In the different large and small towns requirements in shop equipment differ and it is therefore difficult to distinguish a simple trend. The main lines of development followed are not universal; all conceivable intermediate solutions to the problems may be adopted.

(7) Shop Window Lighting

After the war, shop window lighting had to be completely renewed. Before the war shop windows were generally lighted by means of asymmetrical mirror reflectors arranged in the pelmet above the face of the window. For reasons already mentioned, these mirror reflectors were not at first available and on this account there was a very extensive change-over to fluorescent lamps. Because of the low luminance of fluorescent lamps they were often used unshielded and visible to the shop-gazer. The primary consideration was to supply the necessary light and the avoidance of glare seemed to be a secondary matter. The lighting of shop windows with fluorescent lamps naturally resulted in a very diffused lighting which was unsatisfactory for shallow windows and for high ones, too. Reflector fittings for fluorescent lamps will not give the same directional concentration of light as is obtainable with tungsten lamps in mirror reflectors. The use of a louvre, especially one with slanting blades, gave a more directional lighting. Nevertheless this type of lighting was not entirely satisfactory, and reflector spotlights are used more and more, either built into the ceiling or fixed to it with metal supports, the required directional component in the lighting being obtained in this way. Showcases are very frequently to be found in internal passage-ways, the objects shown can be seen from all sides and consequently the shielding of fluorescent lamps, principally by the use of louvres, has to receive special attention (Fig. 6). In the case of dark goods such, for example, as men's wear or ladies' mantles and evening dress, the louvre ceiling appears brighter than the goods. In consequence, some experiments have been made with louvres constructed of plastic containing aluminium powder, which gives a darker louvre and a light distribution with a stronger direct component. A natural consequence of this is that on exhibits of some size such, for example, as dresses, mantles, etc., transverse folds show up distinctly and at the present time the use of these louvres is being abandoned on this account.

(8) Reception Rooms and Accounts Offices

Entrance halls, reception rooms and accounts offices are to-day suitably lighted by a good uniform general lighting which not only provides a high illumination at the

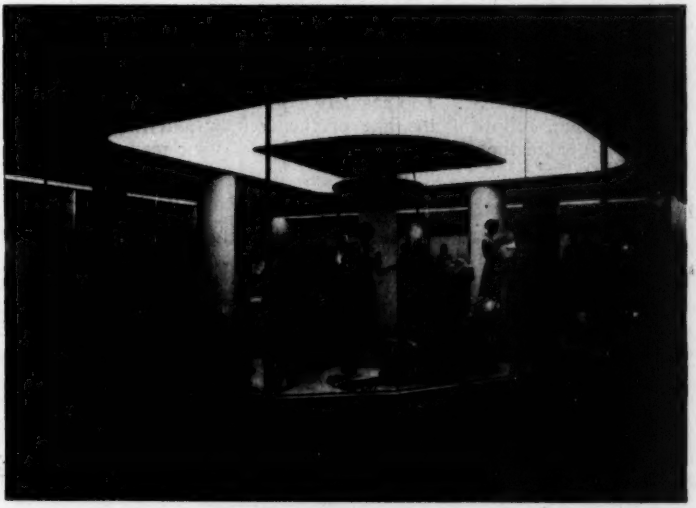


Fig. 6.

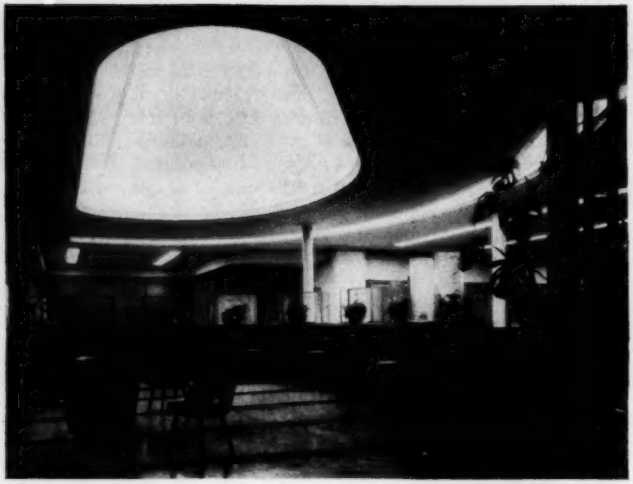


Fig. 7.

working areas, but also shows up the form and lay-out of the room. There is a preference for fluorescent lamps here too.

Accounts offices and the cashiers' halls in banks are often provided with a laylight for the admission of daylight and it is an obvious step to illuminate this laylight artificially as well. Ceilings with an extensive lighting area may easily appear monotonous, as already mentioned in connection with sales rooms. In one banking hall pains have been taken to relieve the monotony of the ceiling, which is of diffusing glass, and to give it a certain interest by subdividing it with metal strips and by making the lighting intentionally uneven. The light and dark areas are produced by arranging the fluorescent lamps behind alternate panels. The counters and the desks behind are specially lighted by tungsten filament lamps in reflectors built into the ceiling.

A tasteful method of lighting a small accounts office without a laylight is shown in Fig. 7. The general lighting of the room is provided by the indirectly lighted area of ceiling in the centre. The cashiers' counter is lighted by a band of light recessed in the ceiling, following the line of the counter and fitted with fluorescent lamps; the desks behind the counter are lighted in a similar manner.

(9) Lecture Rooms

The design of a modern lecture room is influenced not only by the requirement that it should be possible to see well from every seat, but also by the necessity for hearing to be good from every seat as well, consequently the design of the room, especially as regards the walls and ceiling, is largely governed by the acoustics. The result is that, to-day, so-called stepped ceilings are frequently found in such rooms. The lighting system must fit in with the form of the ceiling and walls dictated by the acoustics, and the air-conditioning system of the room has also to be taken care of in the general arrangements. Where the steps in the ceiling open towards the lecturer fluorescent lamps can be fitted quite simply in the gaps, where they will be hidden from the audience. Special lighting of the experimental area and gangways is necessary.

Fig. 8 shows a lecture room with a very good lay-out, in the administration building of a large electrical concern. For æsthetic reasons a stepped ceiling

could not be provided here. The acoustical engineers designed the ceiling to have a series of individual recesses and the general lighting of the room comes from the sides of these. Fluorescent lamp fittings have been built into the ceiling above the windows and these send light obliquely into the room and at the same time light the curtains brightly. With the light reflected from the curtains there is a uniform illumination of the very wide lecture room. The architect has arranged a cornice in combination with the fittings over the window and this also contains fluorescent lamps. When slides are shown the light from these lamps is sufficient to provide a dim illumination of the room for writing notes. The division of the ceiling into recesses suggested that these should be given interest by means of lighting and fluorescent lamps were therefore fitted at the edges of the recesses, the lamps being enclosed in diffusing glassware behind a metal grid. A high illumination of the blackboard and the desk is also provided. The installation can be controlled either in sections or as a whole, so that the room can be given a wide variety of aspects, according to special requirements met with when it is in use.

(10) Theatres

The illumination of the auditorium of a cinema should always be such as to create an appropriate atmosphere. The illumination is not very high, having regard to the dark adaptation needed when the film is being shown. It should, however, be sufficient to enable a seat to be found easily and a programme to be read. For this purpose an illumination of 3 to 6 lm/ft^2 is sufficient. The lighting for atmosphere and for decorative effect can be achieved in different ways. For instance, bare high-

Fig. 8.

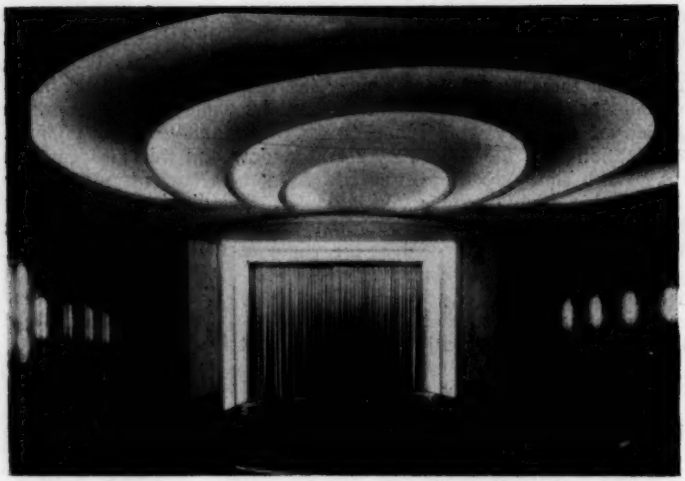


Fig. 9.

voltage fluorescent lamps in ornamental designs are often mounted on the ceiling or on the walls. Alternatively, high-voltage fluorescent lamps, as well as ordinary fluorescent lamps and tungsten filament lamps, are used either enclosed in diffusing material or built into special features of the architectural design. Indirect lighting is very often used and, frequently, fittings on the walls or on the parapets of the circles provide an enlivening addition to the more subdued effect created by the indirect lighting. In such cases, the comparatively small direct component of the lighting is sufficient to enable objects in the auditorium to be seen in the round. Bright areas on the walls give the interior an attractive appearance. Fig. 9 shows a happy solution in which the auditorium is so integrated optically with the stage, and the architecture of the interior is so designed, that the attention of the theatre-goer is guided to the curtain or to the screen. Here, high-voltage fluorescent lamps are mounted in the coves of the ceiling, in the front of the circle and on the gallery. The proscenium arch, too, has red, green and blue high-voltage fluorescent lamps mixed with tungsten lamps. By means of separate dimmers on the different circuits, various attractive lighting effects can be produced in this auditorium.

Theatres and opera houses, because of the way in which they have developed, are generally so-called "box" houses. The auditoria are on this account very high and have several tiers, most of them consisting of boxes. These houses are mostly decorated in ivory, gold and red. Their traditional lighting is from a large central chandelier and small individual lights on the fronts of the tiers.

Some recently built theatres have departed from the principle of the box theatre. The auditorium is often, as in a cinema, an extensive floor with only one balcony above. A modern theatre of this kind is lighted with a large fitting of high-voltage fluorescent lamps. The choice of this type of lighting was not due to the whim of the architect but was made on technical grounds. The fluorescent lamps in the fitting and bronze surfaces behind them conceal a lighting platform which projects downwards from the ceiling into the auditorium. The ceiling in front of the fitting, between it and the stage, is constructed of long rectangular medium-grey wooden panels which are moveable. When the auditorium is darkened these ceiling panels are raised so that a large number of projectors are uncovered and these, together with others in the auditorium, illuminate the stage and especially the apron stage. The projectors

mounted directly on this lighting platform are moved by hand by the lighting men so that the actors or groups of actors can be continuously illuminated as they move about the stage and particularly on the apron stage. This arrangement, adapted to modern methods of stage lighting, has thus been tastefully integrated with the auditorium, since this cylindrical cabin, suspended from the ceiling, has been turned into a central lighting fitting. The number of high-voltage fluorescent lamps used is 124, with a total length of 226.3 metres. A circular panel at the base has a few large tungsten filament lamps which can be used, either in combination with the fitting, or for emergency lighting.

High-voltage fluorescent lamps are favoured for such purposes on various grounds. The tubes can be made in different lengths and forms, and decorative lighting designs in any desired pattern can be created from them. Further, control of the light output from these tubes is comparatively simple.

(11) Churches

The lighting of churches is especially difficult. In particular, buildings of historical interest present the lighting engineer with problems which are very hard to solve. The lighting of churches of the different classical styles of architecture cannot be carried out in any one way, as is shown by the methods used for the natural lighting of different churches. The lighting, too, must differ according to whether the building is a catholic or an evangelical church. The evangelical church is more a meeting room for the congregation; the principal features of the divine service are preaching and congregational singing. The catholic church, on the other hand, has an elaborate liturgy and a great part of the service takes place at the altar. The use of candles shows the significance which light had in the structure of the divine service in early centuries.

The church shown in Fig. 10 is quite modern, built a few years ago. The rectangular nave for the congregation is lighted indirectly with pierced enamel reflectors on the walls, each fitting containing two 300-watt tungsten filament lamps. This high wattage is necessary because the ceiling is lightly tinted. The nave has, in addition,

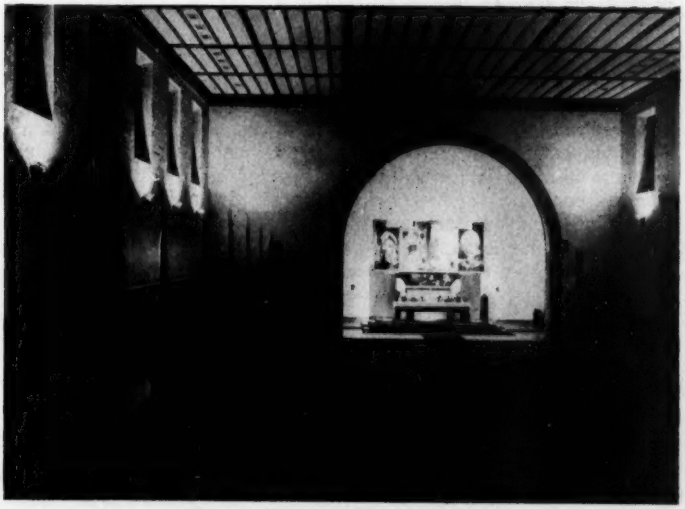


Fig. 10.

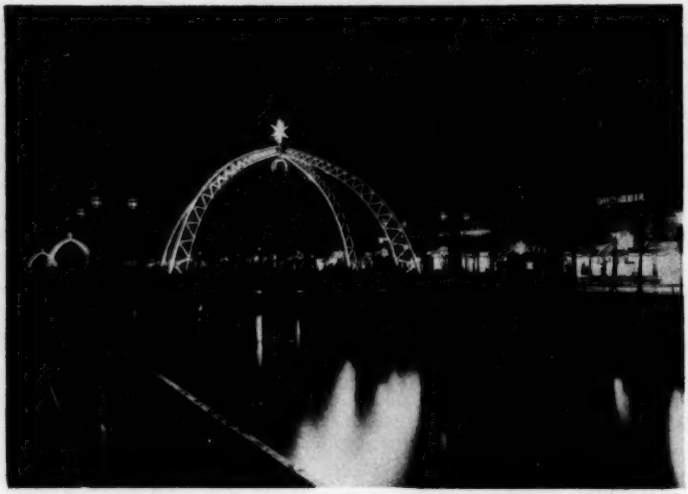


Fig. 11.

direct supplementary lighting from mirror reflectors built into the ceiling at the sides, whilst the sanctuary is lighted from the ceiling with concentrating reflectors, the dense shadows created by this direct lighting being relieved by two trough reflector fittings mounted behind the arch of the choir. The altar itself, which incorporates a copy of the famous Isenheim altar, is caused to stand out against its background by means of four stage projectors with pale yellow filters. One fitting gives a narrow beam of light providing a very high illumination of the monstrance and the tabernacle; two fittings light the altar only when there is no service, so that in the evening it seems to stand alone in the sanctuary. The whole installation can be controlled so that the illumination in different parts of the church can be altered in harmony with the progress of the service.

(12) Festival Lighting

The long familiar use of special decorative lighting of buildings and streets to mark festive occasions, such as town celebrations or the Christmas season, has lately been revived in some towns where, during the weeks before Christmas or at principal shopping seasons, the main business streets are specially illuminated. The installation of these displays is generally the result of collaboration between the commercial interests concerned and the electricity supply authorities. This festive lighting is especially employed in those towns where the shops draw a large number of their customers from the surrounding areas for a considerable distance, so that as many people as possible may be attracted to the shopping streets of the town and induced to make purchases. Fig. 11 shows the Christmas illuminations of 1953 at Düsseldorf.

As regards the illumination of historical or special public buildings, there is not so much to report as in the case of other countries, such as England or France, so here I can refrain from giving examples.

(13) The Lighting of Railways

With the object of increasing the safety of traffic and the convenience of travellers, great efforts have been made to improve the lighting. Some outstanding examples will be described in what follows.

(13.1) Passenger Coaches

Formerly an average illumination of 3.5 to 5 lm/ft² was recommended. Of late these values have been raised to 8 to 15 lm/ft². This increase is desirable for the following reasons :—

In offices, etc., the manuscript to be read remains at rest, whereas in a moving carriage the reading matter is in constant movement relative to the eye and so the letters or words remain focused on the same part of the retina for a shorter time than in the case of stationary text. This causes the reader to tire more rapidly, but he can be helped by an increase of the illumination.

In railway coaches on long-distance trains which travel all night there should be, in addition to the general illumination, an individual light for each seat so that in the night the general lighting can be extinguished and those passengers who cannot or do not wish to sleep, can read by their individual light without disturbing their fellow passengers.

The increased light output of fluorescent lamps makes it easy to provide economically the higher illumination desired. In order to avoid trouble from flicker due to movements of the coach, a frequency of 100 cycles per second is provided for fluorescent lamps run on alternating current. The fluorescent lamps are mounted in dust-proof enclosed fittings on the ceiling of the carriage, the enclosure being made of a diffusing plastic material. The dark ends of the fluorescent lamps in the neighbourhood of the caps are shielded, to make the fitting appear uniformly bright. The current supply is that which has been used for a long time past, a separate 24-volt d.c. generator for each coach, connected in parallel with a battery and provided with a normal type of voltage regulator. Up to now the alternating current is generally obtained by means of a rotary converter, alternators with vibrating contacts not having been so far successful. On the other hand a mercury turbo-alternator has lately been widely introduced with success.

(13.2) Platforms

The increase of illumination in the rolling stock necessitates a much higher illumination on the platforms. The ratio of the illumination in the carriage to that

Fig. 12.

on the platform should not, if possible, exceed 10 : 1. In order to secure safe movement on the platform a good illumination of the ground is necessary, and the average should not fall below 1 lm/ft². This must be associated with the high vertical illumination, firstly for reading the timetables, etc., displayed on the platform and then, even more importantly, for recognising the destination boards, etc., on the coaches. The steps up to the coaches should be free from disturbing shadows, consequently, when the width of the platform is 20 ft. or more the fittings are no longer mounted over the centre line of the platform but near the edge. A new arrangement used in the recently built stations at Heidelberg and Munster is worth noting, and Fig. 12 shows a platform at Heidelberg station. The platform is 33 ft. wide, the fittings are mounted on the platform roof at a height of 16 ft., the distance between fittings being 20 ft. In order to fulfil the requirements described above, a fitting for fluorescent lamps with an aluminium mirror giving an asymmetric light distribution was developed. The polar curve shows a wide distribution towards the centre of the platform, so that a uniform illumination is obtained on the ground. Outwards there is a very strong light emission steeply downwards and this gives a high illumination on the outside of the coach. The mean horizontal illumination is 3.9 lm/ft², and $E_{min}/E_{max} = 22/59 = 1 : 2.7$.

(13.3) Goods-yard lighting

Two systems of lighting have been used hitherto, viz., a decentralised system in which concentrating fittings were distributed evenly over the yard, and a centralised floodlighting system in large yards, where groups of projectors were mounted on one or more towers with their beams directed along the tracks.

In the decentralised system the fittings should provide a wide-angle beam of high intensity in the direction of the tracks. Fittings for tungsten lamps giving an asymmetrical distribution have been used for some time; because of the 1,000-hour life of tungsten filament lamps, these fittings have to be mounted so that they can be lowered. Fluorescent lamps, with their much longer life, make it possible to change the lamps and clean the fittings less frequently. A special fitting for fluorescent lamps has been developed, consisting of two completely dustproof and waterproof enclosed fittings with aluminium mirrors (1 and 2 in Fig. 13). The component fittings are so arranged that the beams cross and glare is prevented because one fitting shields the other. The

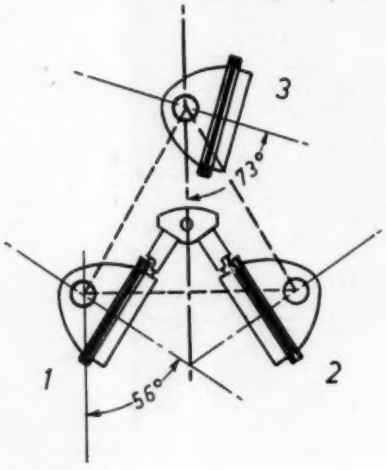


Fig. 13.

fittings are mounted directly on a post and for cleaning and lamp changing, therefore, a ladder has to be used. The fittings are mounted at between 33 and 36 ft. above ground and the distance apart in the direction of the tracks is some 130 ft. and across the tracks about 100 ft. The mean horizontal illumination is of the order of 0.2 to 0.25 lm/ft^2: the uniformity is better than 1 : 5.

It is also possible to combine decentralised lighting with decentralised floodlighting by fixing a third component fitting to the post as shown in Fig. 13. Components 1 and 3 emit light facing the incline while component 2 gives light in the opposite direction. As long as the movement of the waggons has to be watched, components 1 and 3 are switched on, while at the conclusion of this operation normal lighting is provided by switching on components 1 and 2.

Discussion

MR. J. J. CHAPPAT: Because of his long experience in the lighting field, Professor Schneider is specially qualified to speak about the latest developments in Germany and to compare them with what existed before the advent of the fluorescent lamp.

One of the objects of the meetings of our societies is to compare the methods used and the results obtained by countries near to each other—I do not mean just separated by a common frontier but near in the sense of having a similar technical, economical and cultural development. The way of living in Great Britain, Germany and France is very much the same, but it differs greatly from that of the Americans, for example. For this reason, the information given by Professor Schneider is extremely valuable, and conveys the necessary elements for a true comparison with what is being done in our respective countries.

Listening to Professor Schneider, I noted that the technical development of lighting in Germany and France has followed substantially the same course for some 20 years. The advent of the fluorescent lamp upset established lighting methods, and years elapsed before proper lighting fixtures were designed for them. In the meantime, bare fluorescent lamps were used and many lighting engineers thought that all the efforts to fight glare and to educate people about how to avoid it had been in vain.

But although the technical evolution as a whole seems to have followed a similar course in Germany and France, and I suppose, from the little information I have been able to gather, in England too, it is not quite so as regards the artistic side, judging from the samples of fixtures Professor Schneider has shown. This indicates that every country cherishes a definite style and that a change in form and colour comes more slowly than a change due to technical progress. A country may accept and use a scientific development but it will continue to follow its own path in art and thinking. In this, we may find a reason for the difficulty we experience in understanding each other in political affairs.

This being said, I should like to ask Professor Schneider a few questions: I must begin by apologising because I am not going to follow the order he observed in his talk.

Speaking about the lighting in schools, the author told us that, in Germany, fluorescent lamps are used only in school rooms where evening classes are held, and only then if they are to burn long enough to make their use more economical than that of the incandescent ones. This pecuniary aspect has also been considered in France, but for many years past we have had complaints from the Ministry of Education charging fluorescent lighting with all manner of evils. A law allowing the use of fluorescent lighting in schools was enacted last year, but I should like to hear from Professor Schneider if the lighting people in Germany met with similar troubles when they tried to introduce fluorescent lamps into their schools.

When he was telling us about the lighting of stores and shops, the author did not

mention the effect fluorescent lighting has on colours. We had some difficulties at the beginning, especially in butchers' shops, because fluorescent lighting gave the meat a far from appetising appearance. The new Deluxe lamps correct this defect and I should like Professor Schneider to tell us whether, as I suppose, they had the same problem in Germany.

The black ceilings of the so-called "Rotterdam Style" have had little, if any, success in France. Only once have I seen one, at Le Havre. French people generally prefer a lighter surround, attained by the appropriate choice of paint and light quality. The daylight fluorescent lamp, which was a favourite ten years ago, is now superseded by the "White 4500" and a growing tendency to adopt warmer tints, similar to incandescence, is now apparent.

Professor Schneider did not tell us about home lighting in Germany. Is fluorescence used and in what rooms? Which colour do housewives prefer for their lamps? By the way, I want to tell you that a recent survey conducted in Paris showed that 50 per cent. of the kitchens are still lighted by a bare incandescent lamp hanging from the ceiling.

As far as public lighting is concerned, we note that in Germany, as in our own countries, the mercury-vapour colour-corrected lamp competes with fluorescent lamps. One of the defects of these lamps is the spectral quality of their light, which is still not as well balanced as that of tubular fluorescent lamps. Regarding public lighting, I want to tell you of an important project that is now being carried out. The importance is not only due to the intensity of lighting, but to the fame of the avenue where it is being done; it will be finished in a few days. I am speaking of the lighting of the Champs Elysees in Paris.

Those of you who have visited Paris know this vast prospect which extends from the Concorde to the Arc de Triomphe, an area two kilometres long and 65 metres broad. Many will remember that it is lighted by a large number of gas lamps that make a long line of bright spots all along the pavement but do not give enough light on the avenue, which, by contrast, seems still darker. Most probably you will think that the greatest difficulty arose either from the great width of the avenue, or from the trees bordering it on both sides, or from the cost of replacing gas mains by electric cables. We are going to keep the "dear old gas lamps," which will be electrically equipped; in addition new columns approximately 25 ft. high will each carry two lanterns, one to light the avenue, the other to light the pavement. They will be concealed in the trees and will modestly hide their disapproved technical aspect among the foliage. But the double line of gas lamps will remain untouched and the general appearance of the avenue thus remain unchanged.

The last difficulty we met was the colour of the light. The colour-corrected mercury-vapour lamps which we proposed to use—rather than the tubular fluorescent, because they are easier to conceal—gave a greenish light compared with that in the shop-windows and the neon signs of the commercial part of the avenue. We solved this problem by putting two different lamps in each lantern; one is a colour-corrected mercury-vapour lamp, the other a filament lamp. Every old gas lamp on the avenue will also be equipped with a similar pair of lamps.

The important result obtained by the lighting engineers will be specially appreciated by car drivers, because the uniformity of the lighting on the avenue is nearly perfect. The illumination is 1.5 lm/ft^2 in the middle. Formerly, the maximum obtained with gas lanterns was only 0.15 lm/ft^2.

I have talked to you longer than the five minutes allowed to open the discussion, but I thought you might be interested to hear about the important work we have done and the difficulties met, in giving this world-famed avenue the most modern lighting without altering its former appearance, which is so cherished by Parisians and visitors. Those of you who attend, at the beginning of June, our annual meeting in the Loire

Valley, will be able to visit it when crossing Paris, and I hope this will give me the opportunity of meeting many of you again in conference next month.

MR. H. E. G. WATTS: A couple of relatively straightforward points which appear to be of great interest to lighting engineers in this country arise from street lighting practice in Germany. First of all, I see that most of the tungsten filament lighting is used with the lamps operating vertically as we use them in this country, but they are surrounded by an opal cylinder giving a light distribution which would indicate a necessity for rather close spacing, and I would like to know if Professor Schneider could give us an indication of the spacing normally used with these lanterns.

The second point of interest is the comparative popularity of the various types of light sources used for street lighting. These are most interesting to us, particularly the great popularity of fluorescent lamps. Could Professor Schneider give us some forecast of the change in relative degrees of popularity of the various light sources in the future?

MR. H. LONG: I was interested to hear Professor Schneider and M. Chappat say that they are using the fluorescent bulb lamp. I really think that, when we have had more experience and more development in this country, it will be a very important light source.

MR. A. H. NASH: Referring to the section on shop lighting, it would be useful to have some further comments from Professor Schneider on the question of desirable ceiling brightness patterns.

The author states that for low ceilings, darkness is an advantage compared with a lighted treatment, because in that way you lose your low-ceiling oppressiveness or "shut-in" effect.

Earlier this week, Mr. Hewitt mentioned our old axiom about avoiding the lowering or "tunnel" effect of unlighted ceilings, but he suggested that it is getting a little rusty. This appears to be a contradiction, and I therefore suggest that the dark-ceiling treatment should be used whenever we are aiming at an illusion and want to lose an undesirable appearance arising from the ceiling being either too low or too high.

Referring to the section on shop windows, is there any tendency in Germany for mirror glass reflectors to be used instead of expendable reflector spot lamps?

MR. T. L. ROBINSON: I should very much like to ask Professor Schneider if he can give us some information regarding the lighting of secondary roads. What type of lighting does he advocate, or what type of lighting is used in Germany, and also, is the use of the new high-pressure fluorescent mercury lamp influenced at all by the cost of energy? Is the lack of favour of sodium lighting in Germany influenced by the cost of energy, or is it due to any other particular fact?

MR. A. R. MCGIBBON: There are one or two questions I would like to ask Professor Schneider on the railway portion of his interesting paper. He mentions the use of fluorescent lighting in trains. Do I gather from this that fluorescent lighting will be used as a standard means of lighting carriages in future in Germany, or is it intended only for special, perhaps international, trains? He mentions the problem of converting from direct current to alternating current and I would like to know what overall efficiency of conversion has been obtained, that is, from the battery watts to the lumens from the lamp. He also mentions in passing the mercury turbo-alternator; perhaps he could give more details of this in his written reply.

Referring to the special lighting fitting described for use in goods yards, he

mentions a mounting height of 33-36 ft. above the track and that maintenance would be carried out by means of a ladder as distinct from using raising and lowering gear. Does that mean fixed ladders would be employed, because we would not, in this country, allow men to carry portable ladders around a busy yard? In marshalling yards, as distinct from goods yards, would a higher mounting height than 36 ft. be used and had they used floodlights at 100 ft. or even 150 ft. above ground?

Finally, when passing through stations in Germany and other Continental countries last year I noticed that the fluorescent lighting fittings appeared to contain one or two lamps about 4 ft. long, so I concluded they were housing 40-watt lamps, but they seem to be very much brighter than the 4-ft. 40-watt lamps used in this country. Are they, in fact, 40-watt lamps or are they of a greater wattage than those available in this country?

MR. G. C. SMALL (written contribution): I was interested to learn that in Germany there is now a growing tendency to favour the high-pressure mercury vapour lamp with fluorescent bulb as against the normal fluorescent tube, and should be grateful if Professor Schneider would be good enough to let us have information on the following points so that a comparison can be made which will take economics into account: (1) What is the average price of electricity per kilowatt hour? (2) What is the price of the H.P.M.V. 250-watt lamp, its useful nominal life in burning hours and the average lumen output throughout the life? (3) The cost of a street-lighting lantern to house a lamp of the type referred to above, together with the price of the ancillary gear. (4) The price of 40-watt fluorescent-type lamps and the number required to give approximately the same lumen output as the 250-watt mercury lamp. (5) The price of the lantern and ancillary gear to house the fluorescent lamp.

Would the Professor also tell us whether the general public prefers fluorescent lighting to mercury and, if so, what reason do they give for such preference.

PROF. L. SCHNEIDER (in reply): M. Chappat has asked several questions about the use of fluorescent lamps in Germany. Their introduction into schools has not given rise to any complaints from the users. Regulations regarding school lighting refer to such matters as intensities, uniformity, glare and the like; the choice of source is mainly governed by economic considerations. When these lamps were first used in butchers' shops it became clear that certain colours were unsuitable. High values of illumination by daylight lamps were quite satisfactory but uneconomical, and lamps with a high red content are to-day most commonly used, often in combination with filament lamps. Now that the solution to the problem has been found, the use of fluorescent lamps in this type of shop has greatly increased.

The fluorescent lamp has made very slow progress in home lighting, and at the present time relatively few homes are lighted in this way. Precise information is not so far available, but it can safely be said that the room most frequently lighted with fluorescent lamps is the kitchen. Inquiries as to the colours used have so far given inconclusive results, although it might naturally be expected that since the problems were similar to those met with in butchers' shops, either daylight colours or lamps with a high red content would be preferred. For living rooms lamps should have a pronounced red component since they are often supplemented with filament lamps, in standards or in table lamps, for example.

According to a survey carried out among the employees of a large lamp manufacturing concern, the proportion of homes in which a fluorescent lamp is used increases with the size of the dwelling, varying from one in every two homes with four rooms or over, to one in every 12 homes with one room, the overall average being one in every four homes. In connection with these figures it must be remembered that the

employees of a lighting firm are especially receptive to these new sources, and the figures given are not applicable generally. The 2,042 fluorescent lamps used are distributed among the different rooms as follows:—

Kitchen	40 per cent.	Hall	8.3 per cent.
Living room	29 per cent.	Boxroom, bathroom, etc. ..	7.8 per cent.
Bedroom	9 per cent.	Other locations	5.9 per cent.

The reply to Mr. Watts's question about the spacing/height ratio of the fittings with tungsten lamps and opal glass cylinders is that, with mounting heights of 23 to 33 ft., the ratios most commonly adopted hitherto have been between three and four. In new installations using this type of fitting it is recommended that the ratio should be from two to three in order to comply with the Code of Practice for Street Lighting (DIN 5044) as regards illumination values and uniformity.

The percentage of fluorescent and H.P.M.V. lamps in use is increasing and that of filament lamps and mercury-tungsten lamps is decreasing. (The term "H.P.M.V. lamp" is used here to include lamps both with and without fluorescent colour-correction. Accurate information regarding these two types separately is not available, but it can be said that the overall increase here mentioned is attributable to the colour-corrected lamp.) The sodium lamp is hardly used at all in built-up areas; hence its small percentage of the total, viz. less than one per cent., since the lighting of country roads, apart from a few exceptional cases, is not contemplated at present.

My remarks about the use of a darkened ceiling have apparently been misunderstood by Mr. Nash. I am definitely of the opinion that the boundary surfaces of a room should be clearly visible; the appearance of a room is distorted if the ceiling is dark. The two shops I mentioned are special cases in which for a particular reason the ceilings and the upper surfaces of the walls are kept dark. In one case the object was to conceal a change of ceiling height and to create the impression of a uniform height throughout the room; in the other it was desired to prevent services which had to be mounted below the ceiling being seen. I remarked that the success of such installations seemed to be greater the larger the fraction of ceiling surface that was illuminated.

So far from reflector spot lamps being replaced by lamps in glass reflectors, the tendency is in the reverse direction; more and more reflector lamps are being used. For the production of small areas of high illumination, low-voltage lamps in aluminium reflectors are at present much in favour.

Mr. Robinson inquires about the lighting of side roads. In the past these roads were generally lit by filament lamps at long spacings, giving beacon lighting rather than street lighting. More recently the colour-corrected mercury lamp has been increasingly used, side by side with the fluorescent lamp, preferably circular or U-shaped. In view of the less exacting demands made on the lighting in side roads, mounting heights of 10 to 17 ft. are used with spacings up to 128 ft. The fittings are generally mounted direct on posts or on short bracket arms.

The greater efficiency of the colour-corrected mercury lamp certainly influences its popularity, but other factors such as life, ease of maintenance, glare, etc., have also to be considered. The high efficiency of the sodium lamp fails to over-ride the disadvantage of its colour where the lighting of built-up areas is concerned, but it is used for outer roads, main traffic routes, etc.

The answers to Mr. Small's questions are: (1) There is a very wide variation in the cost of current for street lighting but the average can be taken as about DM 0.12 (about 2½d.) per kwh. (2) The price of the 250-watt colour-corrected lamp is DM 29.40 (50s.). Its average life is 5,000 hours, while the initial lumen output is 11,000 and the average throughout life 9,350. (3) The price of the fitting varies greatly from about DM 100 (£8 10s.) for an enamelled reflector fitting with opal glass cylinder to about three times that figure for an upright fitting. (4) The 40-watt fluorescent lamp

costs DM 4.70 (8s.) and its life under street lighting conditions is about 6,000 hours. The initial lumen output is 2,150 and the average throughout life 1,830, so five of these lamps are approximately equivalent to one 250-watt colour-corrected mercury lamp. (5) The prices of lanterns and auxiliary gear depend greatly on the design and construction, ranging from about DM 144 (£12 4s.) for a fitting housing a single lamp to DM 265 (£22 10s.) for one housing two or three lamps. A fitting housing a large number of lamps costs more, the price for a 24-lamp fitting being DM 1,540 (£130).

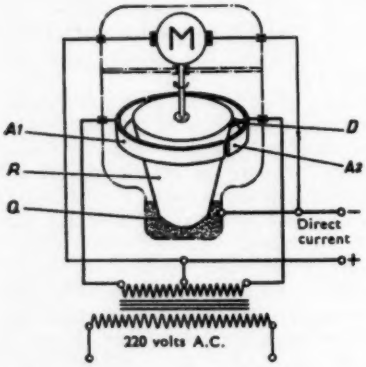
Finally, as regards public preference, it may be said that the uncorrected H.P.M.V. lamp is not used for street lighting, except in combination with tungsten and these installations are being replaced with colour-corrected mercury, which is becoming increasingly popular. Whether this lamp will check the further expansion of fluorescent lighting remains to be seen. Some towns prefer fluorescent because of its lower brightness (with less glare), its better colour and the breadth of the reflection produced on a wet road surface when the lamp is mounted transversely. Other towns prefer the mercury lamp because of the higher light output per lamp, the simpler maintenance and the lighter weight of the fitting, an important matter with overhead suspension.

Mr. Small's questions indicate a desire to make a comparison in figures between the two types of lighting, but this should be done only with the utmost caution. As will be seen from the remarks just made, there are many advantages and disadvantages in each system which cannot be expressed numerically.

The reply to Mr. McGibbon's first question is that nearly all new passenger rolling-stock has fluorescent lighting and some of the older rolling-stock is being converted. Supplementary lighting is by tungsten lamps. The overall efficiency, expressed as lumen output (of a warm-white lamp giving 1,850 lm.) divided by the power taken from the battery is, at full load,

(a) d.c. to a.c. by turbo-converter .....30 lm/w
(b) d.c. to a.c. by rotary converter .....21 lm/w

The turbo-converter (Turbowechselrichter) used to convert 24 volts d.c. to 220 volts a.c. operates at an efficiency of up to 85 per cent. It is shown in the diagram. In an



Showing principle of turbo-converter

air-tight chamber filled with an inert gas, a small motor, M, drives a vertical conical tube, R, the lower end of which dips into a pool of mercury, Q. When the speed of rotation is high enough, centrifugal force causes the mercury to rise in the tube and to emerge in a narrow jet from the nozzle, D. The rotating jet of mercury impinges on the cylindrical contact ring and connects the negative of the d.c. alternately to the ring segments A_1 and A_2 which feed the primary of the transformer; the secondary

of this gives the 220-volt a.c. supply. This converter is free from contact troubles, it is unaffected by vibration and shock, while tilting up to 30 deg. from the vertical does not interfere with its operation.

Maintenance of the twin lighting fitting in goods yards is carried out without portable ladders, since the supporting post acts as a ladder. The glass cover plates are easily cleaned and can be readily opened for re-lamping. Mounting heights do not exceed 33 to 36 ft. Hitherto, floodlights mounted at 115 to 145 ft. have been used in large marshalling yards but it is intended to replace these with the combination of decentralized floodlighting and triple fittings referred to in the paper.

The fittings used in stations generally house one fluorescent lamp, either 4 ft. 40-watt or 5 ft. 65 watt. Frequently these fittings have anodized aluminium reflectors which increase the luminous intensity in desired directions and this gives the impression of a higher brightness.

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